Technological Innovation in Amateur Radio

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Post Presentation Version

This presentation was given at the SEA-PAC 2025 conference in Seaside, Oregon, USA on 2025-05-31, 13:00 - 13:50 at the Seaside Convention Center, Seaside A room, to a full room.

This version of this slide deck is intended for post-presentation.

This version of this slide deck includes hyperlinks to websites that were not present in the original presentation, as well as other minor formatting and other tweaks.

The links provided are not intended to be authoritative or a complete treatment of the subject, but rather “just a bit more detail” about the subject. Some links to Zero Retries are provided to articles that best illustrate the idea or the project.

Every topic in this slide deck has been covered *multiple* times, often in depth, in the Zero Retries newsletter.

Technical Innovation versus *Technological Innovation*

ChatGPT says:

Technical:

Meaning: Relates to *specific* skills, methods, or details of a particular field or subject — often focused on *how* something works.

Technological:

Meaning: *Relates* to technology — the *use* of machines, tools, or scientific knowledge to solve problems or perform tasks.

Amateur Radio is Doing *Technological* Innovation

We're *using* technology in new and different ways in this era, such as:

- Using software to *write* new radios.
- Tackling solved problems like proprietary CODECs with open source approach (M17 Project).
- Adopting new techniques like when a packet fails CRC test, try bit flipping of every packet received to correct a single bit error. (Dire Wolf Software TNC)
- Wasting bits like creating modem software that's demanding enough to require a Raspberry Pi 5 to run it (Free DV Radio Autoencoder - RADE).
    - Buy a Raspberry Pi 5 is $120 for 8 GB RAM - an appliance.

The Goal of This Presentation…

Zero Retries: https://www.zeroretries.org

- "Expand your horizons" about just how *much* technological innovation is actually occurring… now (present day) in, and adjacent to Amateur Radio…
  - That you're *not hearing about* in the "mainstream" Amateur Radio media.
- I got so frustrated at not seeing the technological innovation in Amateur Radio in the "mainstream" Amateur Radio media *that I knew was occurring…*
  - I started my own newsletter - **Zero Retries**.

M17 Project

https://m17project.org/

- *Open source* digital voice and data system
- No proprietary technology
- CODEC for voice is Codec 2 - specification and software
- Full ecosystem of devices, including repeaters and now radios (off the shelf) - Connect Systems CS7000 M17 portable radio
- Includes data
- Extensible - experimental digital signing of each transmission
- Bringing in new Hams that *really care* about Open Source

AREDN

https://www.arednmesh.org/

- Amateur Radio Emergency Data Network
- Repurpose Wi-Fi and Wireless Internet Service Provider microwave networking hardware with new firmware
- Unique requirements of Amateur Radio such as callsign and no encryption
- Plug and play mesh networking, handles “fussy bits” like DHCP assigns IP addresses, etc.
- Mesh networking that really does “just work… now even better with “Babel” mesh network protocol versus older OLSR mesh network protocol.

MMDVM - Multi Mode Digital Voice Modem

https://github.com/g4klx/MMDVM

- Designed to get Amateur Radio back into hacking repeaters for Digital Voice
- Putting a MMDVM into an FM repeater enables all kinds of new capabilities
  - All DV modes - P25, D-Star, System Fusion, Digital Mobile Radio
  - Paging
  - MMDVM-TNC
    - Various data modes including 19200 bps with FEC
    - We finally have a way to do data, cleanly, over repeaters
  - M17

New Packet Radio

https://hackaday.io/project/164092-npr-new-packet-radio

- No commonality with AX.25 Packet Radio
- Designed by Amateur Radio Operators for Amateur Radio in Europe
- High speed data only mode based on TCP/IP with Ethernet interface
- 100 kbps in a 100 kHz channel
- 1 Mbps in a 1 MHz channel
- Hopefully FCC will delete symbol rates and bandwidth limits on VHF / UHF as many requested in FCC Docket 16-239 followup and “delete, delete, delete”

GEO Satellite for Western Hemisphere

(Recent activity) https://amsat-dl.org/wp-content/uploads/2025/05/AMSAT-Organisations-futureGEO-RFEI.pdf

- Serious case of QO-100 envy; geosynchronous Amateur Radio payload above Africa, Europe and much of Asia
  - 2.4 GHz uplink, 10 GHz downlink
  - QO-100 is driving all kinds of interesting experimenting - new radios, new modes,
- European Space Agency (ESA) has put out request for proposals for another GEO Amateur Radio payload (or small satellite) that would at least partially cover Canada (who is an ESA member country) and partial coverage of US

902 - 928 MHz Band

https://www.zeroretries.org/i/157918236/the-threat-to-the-us-mhz-cm-band-from-nextnav

- Hams have overlapping privileges with unlicensed (Part 15) users
- Fair number of analog FM repeaters, noise is less at band edges
- FCC Docket 24-240, NextNav proposes privatizing 15 MHz of the band and pushing Amateur and all Part 15 into 11 MHz in the middle of the band.
  - Lots of pushback! Automatic toll collection, RFID tags in retail, building automation, automatic meter reading
- 902-928 MHz is getting more interesting for data - new standard drove new hardware - 802.11ah / HaLow, and most of Meshtastic (in the US) operates there.

219 - 220 MHz Band

https://www.zeroretries.org/i/150771111/revisiting-the-us-amateur-radio-mhz-band

- Requirements for usage include *data* only and *point-to-point links* only.
- Amateur Radio usage is secondary to commercial users operating under spectrum leases.
- Had ridiculous “permission” structure, which doesn’t work at all (some have tried).
- Open Research Institute (ORI) is working to get notification rules removed.
  - Amateur Radio will still be secondary to commercial users.
- BridgeCom Systems BCM-220 is only radio that works in this band
  - It’s a pretty decent data radio.

Digital Amateur Television (DATV)

https://kh6htv.com/wp-content/uploads/2021/02/an-55a-atv-handbook-1.pdf

- Full motion, good image quality in 2 MHz, based on open specification for satellite digital television
- Kind of a stealth mode in Amateur Radio
- Recently learned that DATV can be received with an inexpensive USB Software defined receiver
- Idea - Every metro area ought to have a DATV repeater; could be streaming videos about Amateur Radio - *on Amateur Radio*
  - Imagine the impact that could have that Amateur Radio isn't just Morse Code on HF

VARA FM and VARA HF

https://rosmodem.wordpress.com/

- VARA is a high speed, high performance, highly reliable modem software
- HF version is one of highest performance data modes - 7050 bps
- FM (VHF / UHF) version is the highest performance on a standard VHF / UHF channel and radio - 25210 bps
- Runs on Windows, highest performance requires purchase of a license
- Highest performance requires a radio with flat audio connection and high resolution audio adapter (modem)
- What's different about VARA is that it illustrates what is possible (and works very well)
  - But it's proprietary; an open source equivalent called Mercury is in development

Open Source Equivalent to VARA

https://github.com/Rhizomatica/mercury

- Rhizomatica Mercury Modem is an open source software project intended as a “drop in” replacement for VARA HF.
- Mercury should be as usable on wider, quieter channels on VHF / UHF as VARA FM.
  - I asked at Hamvention 2025, and they said “yes, probably, though our focus is on HF”.
- Will nicely fix the plaints about VARA HF - Will run on Linux, Open Source for community input / modifications / forks, and no fees for using at highest speeds.

ka9q-radio

https://ka9q-radio.org/

- ka9q-radio is software that runs on a host computer that takes the entire bandwidth of a software defined receiver and parses out individual radio channels - all of them, simultaneously
  - Not typical sequential scanning
- Example - can monitor and record all 2m (144-148 MHz) repeater and simplex channels
- Recent development is ka9q-web which puts a graphical user interface on ka9q-radio

Communication and Telemetry System (CATS)

https://cats.radio

- Next generation idea for doing APRS
- Operates on 440 MHz instead of 144.39 MHz
- Operates at 9600 bps instead of 1200 bps
- Uses raw Frequency Shift Keying instead of Audio Frequency Shift Keying
- Transmits with Forward Error Correction - typical APRS does not have FEC
- Keeping with the “cat” theme, the Internet infrastructure is called FELINET

APRS Messaging

https://www.zeroretries.org/i/147797445/aprs-messaging-being-covered-by-jason-oleham-kmack-videos

- Boring old APRS, right?
- Meshtastic is showing that messaging is a hot, interesting capability
- APRS has had it nearly from the beginning, but no sexy apps
- APRS Droid app for Android, APRS.FI app for IOS both have messaging section, but not “messaging first” app like Meshtastic
- To show off Amateur Radio, need to develop messaging first apps that are as sexy as Meshtastic

IP400 Network Project

https://ip400.adrcs.org/

- Developing next generation data communications radios and networking in the Amateur Radio VHF / UHF band
  - IP400 radios use radio chipsets designed for data communications for Internet of Radio Things
  - Higher speeds - minimum 100 kbps
  - Automatic mesh network discovery and automatic routing
  - Compatibility with existing networks, protocols, and modes by encapsulation. For example
    - At the origin, AX.25 is encapsulated in a IP400 frame
    - Transported through the network
    - Unencapsulated at the destination
  - There will be an adapter for FM repeaters to handle IP400 - Supernode!

ARDC - Venture Funding and 44Net

https://www.ardc.net/

- Predecessor of ARDC obtained a Class A IPv4 address block - 16M IPv4 addresses
- Eventually sold 25% - 4M IPv4 addresses to create an endowment
- Now award grants of $5M+ annually
- Fund many new technology development such as MMDVM, FreeDV, and M17 Project
- Remaining 12M IPv4 addresses is called 44Net
- ARDC is prototyping an Amateur Radio Virtual Private Network (VPN)

Packet Radio Renaissance

https://www.zeroretries.org/i/84565746/zero-retries-omnibus-of-zero-retries-interesting-information

- Networks are coming back
- EASTNet
- Microwave
- Terrestrial Amateur Radio Packet Network / NCPACKET
- MMDVM-TNC - data on repeaters!
- IP400 soon, including using repeaters adapted for IP400

Software Defined Radio

https://www.gnuradio.org/

- You can specify *exactly* what the waveform will be
- Hams are back in the technological innovation game now that we can innovate in software
- Best example was a mention of “I needed a different radio, so I sat down and wrote one”
- Hardware is capable and easy and cheap for HF because frequencies are 50 MHz and lower.
- We’re not at “easy and cheap” yet for VHF / UHF SDR, at least for transmitting
  - Software Defined *Receivers* for VHF / UHF is a solved problem
- The easy way to get involved with SDR is GNU Radio
  - Graphical User Interface for GNU Radio is Gnu Radio Companion

Digital Library of Amateur Radio & Communications (DLARC)

https://archive.org/details/dlarc

- I really, really love DLARC
- Project of the Internet Archive (parent of Wayback Machine).
- Worldwide library for Amateur Radio (and loosely related communications).
- More than 1M items, all free to read, most free to download. A lot (most) of DLARC material has never been online before DLARC.
- Fantastic technical resource - inspiration for ideas we tried, things we accomplished. Examples - TEXNET, PACSAT, Packet Radio Magazine, many microwave conferences, AMSAT's ORBIT magazine, etc.
- Funded by a grant from ARDC. A second ARDC grant in 2025 funded DLARC for an additional two years.

Hometown Audience, a Few Local Mentions

- **HamWAN** - http://hamwan.org/
  - Amateur Radio microwave network in Western Washington
  - Unlike most such networks, HamWAN is user accessible!
- **HuskySat-2** - https://huskysat.org/ and https://newsletter.huskysat.org/p/fall-2024-hsl-update
  - UW has a group that is building a second experimental satellite and will include Amateur Radio capabilities on it using Software Defined Radio unit

Hometown Audience, a Few Local Mentions

- **Puget Sound Amateur Radio TCP/IP Network**
- https://www.superpacket.org/2021/03/the-puget-sound-amateur-radio-tcpip-network-circa-1995.html
  - We were doing TCP/IP, over Amateur Radio UHF repeaters, at 9600 bps, back in 1995.
  - *That's how I know* that data over repeaters works great!

Hometown Audience, a Few Local Mentions

Two amazing conferences in September 2025 in Everett, WA!

GNU Radio Conference 2025

September 8-12

https://events.gnuradio.org/event/26/

Total immersion in Software Defined Radio!

Hometown Audience, a Few Local Mentions

Two amazing conferences in September 2025 in Everett, WA!

Zero Retries Digital Conference

September 13

https://www.zeroretries.org/p/conference

Carefully curated Zero Retries Interesting agenda!

Zero Retries Newsletter

www.zeroretries.org

- Substack will “encourage” you to select a paid subscription, but just pick the free one.
- Paid subscriptions are appreciated, and help keep Zero Retries going, but not required.
- Publishes every Friday at 15:30 Pacific… usually
- Feel free to email me with ideas - steve@zeroretries.net

Zero Retries Newsletter

Questions?

I will release this slide deck to SEA-PAC for publication with the other seminars, with URLs pointing to each project.